

## Open Fractures: Wash-out and to OR next day? What really decreases infection?

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### Factors for risk of infection

- (1) Failure to utilize prophylactic antibiotics;
- (2) Resistance of wound organisms to wound antibiotics;
- (3) Increased time from injury to initiation of antimicrobial agent !
- (4) Extent of soft tissue damage;
- (5) Open tibial fractures;
- (6) Wound closure in the presence of *C. perfringens*

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### Where did we get the 6 hour rule?

- **1898** Friedrich's experimental tissue contamination studies in **guinea pig** soft-tissue wounds, which limited the time interval for effectiveness of operative debridement to ~6 h



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**Timing of Debridement and Infection Rates in Open Fractures of the Hand: A Systematic Review**

Constantinos Ketonis<sup>1</sup>, Joseph Dwyer<sup>1</sup>, and Asif M. Ilyas<sup>1</sup>

**META-ANALYSIS**

Overall infection rate:  
 -4.2% debride ≤ 6 hours  
 -3.6% debride within 12 hours

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**Antibiotic Management and Operative Debridement in Open Fractures of the Hand and Upper Extremity**

William J. Wamender MD, Christopher J. Lucasi BS, Tala R. Chapman MD and Asif M. Ilyas MD

**META-ANALYSIS**

Infection rate:  
 No diff < or > 12 h  
 Not all received abx even

Reference	Location of Fracture	Noninfection		Infection		P Values (Antibiotics vs Late or No Antibiotics)
		Antibiotics/Early Administration	No Antibiotics/Late Administration	Antibiotics/Early Administration	No Antibiotics/Late Administration	
Blian et al, <sup>5</sup> 1997	Distal phalangeal	71	7	2 (2.8%)	3 (20%)	.0200
Ng et al, <sup>6</sup> 2014	Hand	53	9	0	8	.0072
Ketonis et al, <sup>7</sup> 2017	Hand	1330	155	61 (4.4%)	16 (9.4%)	.0057
Cisno et al, <sup>8</sup> 2011	Hand	143	0	2 (1.4%)	0	---
Bugrook et al, <sup>9</sup> 1990	Phalangeal	43	44	2 (2.1%)	2 (2.1%)	---
Summing et al, <sup>10</sup> 2014	Forearm	150	40	6 (6%)	1 (2%)	.4000
<b>Total</b>		<b>1790</b>	<b>245</b>	<b>70</b>	<b>30</b>	---

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**The Hand is NOT the Tibia!**

**So What's that evidence**

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Research Article

**Management of Open Tibial Shaft Fractures: Does the Timing of Surgery Affect Outcomes?** JAAOS-2017

Oscar A. Duyos, MD  
David Beaton-Comulada, MD  
Ariel Davila-Parrilla, MD  
Jose Carlos Perez-Lopez, MD  
Krystal Ortiz, BS  
Christian Foy-Parrilla, MD  
Francisco Lopez-Gonzalez, MD

227 patients: Grade I to IIIA

No difference in 24-48h vs 48-96h

Gustillo Grade:

I-	9%	~	11%
II-	15%	~	20%
III-	27%	~	29%

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227 patients: Grade I to IIIA

No difference infection rate in 24-48h vs 48-96h

Infection rate related to definitive fixation:  
Definitive Exfix (26.8%) >>> IMN (14.9%)

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**The list goes on and on...**

Namardi et al	J Orthop Trauma	2011
Werner et al	JAAOS	2008
Khatod et al	J Trauma	2003
Skaggs et al	JBJS Am	2005
Bednar et al	J Orthop Trauma	1993
Jarley et al	J Orthop Trauma	2002
Leonidou et al	Strategies Trauma Limb Recon	2014
Rozell et al	Orthop Clin North Am	2017
Nobert et al	J Trauma Manag Outcomes	2016
Duyos et al	JAAOS	2017
Spencer et al	Ann R Coll Surg Eng	2004
Bosse et al	N Engl J Med	2002
Pollak et al	JBJS Am	2010
Schenker et al	JBJS Am	2012

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## Modern Day Timing: Debridement of Open Fractures

- When?
  - 6.8% <12hrs vs 7.1% >12hrs (Patzakis et al CORR 243, 1989)
  - 9.0% <8hrs vs 10.0% >8hrs (Harley et al JOT 16(7), 2002)
  - 1.6% <6hrs vs 2.5% >6hrs (Skaggs et al J Paed Orth 20(1), 2000)

Most North American and European Studies look at < or > 6-12 hours  
Many show that due to a variety of reasons ~40% don't get to OR in 6 hrs

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If timing doesn't matter...

So then what matters ???

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### Open Fractures: It Doesn't Come Out in the Wash

Surgical Infections: 2011

Lisa L. Schlitzkus, Claudia E. Goettler, Brett H. Waibel, Scott G. Sagraves, Christopher C. Hasty, Melinda Edwards, and Michael F. Rotondo

	No complication	Complication	p value
Age (years)	37.6 ± 18.4	37.6 ± 15.7	0.972
SS	12.6 ± 9.9	17.4 ± 11.8	<0.001
RTS	11.0 ± 2.4	9.7 ± 3.5	<0.001
AS	2.6 ± 0.7	2.9 ± 0.5	<0.001
Time to washout (min)	506 ± 341	550 ± 491	0.497
Gustilo grade	2.2 ± 0.8	2.2 ± 0.7	<0.001
Percent blunt injury	73.4	84.3	<0.001
Percent male	73.3	85.2	0.089
Ethnicity (%)			
White	53.0	48.4	0.488
Black	37.5	39.3	
Other	9.5	12.3	
Percent lower extremity fractures	62.6	78.7	<0.001

	Adjusted odds ratio	95% Confidence interval	p value
Male sex	2.92	1.63, 5.21	<0.001
Revised Trauma Score (per unit decrease)	1.12	1.06, 1.20	<0.001
Penetrating trauma	0.169	0.072, 0.395	<0.001
Fracture Gustilo grade			
2	1.64	0.785, 3.41	0.189
3A	3.10	1.39, 6.90	0.006
3B	8.90	4.30, 18.4	<0.001
3C	4.61	1.80, 11.8	0.001

What matters most is Mechanism / Gustilo Grade and RTS

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**Aggressive Treatment of 119 Open Fracture Wounds**  
DeLong, William G. Jr. MD; Born, Christopher T. MD; Wei, Steven Y. MD; Petrik, Mark E. MD; Ponzio, Robert DO; Schwab, C. William MD

Immediate in Grade I – IIIA?

**When to close the wound ???**

Timing of Wound Closure in Open Fractures Based on Cultures Obtained After Debridement

By Christopher J. Lenarz, MD, J. Tracy Watson, MD, Berton R. Mood, MD, Heidi Israel, PhD, RN, J. Daniel Mullen, MSPH, BA, BS, and James R. MacDonald, BS

After negative cultures?

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Trying to AVOID →  
Post-Traumatic Infections/Osteomyelitis

- Most common organisms:
  - S. Aureus, Ps. Aeruginosa, S. Epi, G- Rods
- Systemic Abx in open fx → TREATMENT
  - Not prophylaxis

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Systemic Antibiotics in Open Fractures

- Significant reduction of infection if given early, irrespective of timing of debridement.
  - 14% to 3% for all comers, if use abx.  
(Patzakis et al JBJS 56A:532, 1974)
  - 4.5% if <3hrs, 7.5% if >3hrs  
(Patzakis et al CORR 243:36, 1989)
- The group receiving antibiotics had a 78% lower rate of infection compared with controls.  
(Cochrane Review 2004)



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### Role of Antibiotic Beads

- Excellent local high concentration Abx delivery
  - Seligson (1993) and (1993)
  - Mohring (2000) Keating (1996)
- Useful for dead space management
- Fill bone voids in open fractures
- Place directly under VAC ??
  - No clinical studies supporting this




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### Antibiotics Beads in Open Fractures

- Antibiotic Bead Pouches:
  - Grade 2 fractures:
    - Reduce infection rate from 15-20% to 3-4%
  - Grade 3 fractures:
    - Reduce infection rate from 20-44% to 4%



(Henry et al J Trauma 30(10), 1990 and CORR 295, 1993)  
(Keating et al J Ortho Trauma 10(5), 1996)

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### What antibiotics can be used w/ PMMA?

Antibiotics Used in Antibiotic-Impregnated Cement

Can Be Mixed With Cement	Decreased Activity Because of Cement Heat	Adversely Affected by Cement Curing
Amikacin	Cefazolin	Erythromycin
Amoxicillin	Cephalothin	Gentamicin
Ampicillin	Ciprofloxacin	(powder)
Bacitracin	Clindamycin	Lincomycin
Cefamandole	(powder)	Methicillin
Cefazolin	Colistin	Novobiocin
Cefuroxime	Daptomycin	Oxacillin
		Penicillin
		Polymyxin B
		Streptomycin
		Ticarcillin
		Tobramycin
		Vancomycin
		Chloramphenicol
		Colistimethate
		Tetracycline
		Liquid gentamicin, clindamycin, etc (because of aqueous content)
		Rifampin

Joseph T, et al: JAAOS Jan / Feb2003

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### Concentration / Cement

- Up to 3.6 gm tobramycin and 4 gm vancomycin
- Practical 2.4 T : 2.0 V
- Palacos w/ best elution???



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### Bead Pouch



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Where does the VAC fit in?

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**Vacuum Assisted Closure**

- Semi-sealed wound coverage
- Stimulates granulation tissue



Barnaby (2007) Herscovici (2003)

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## VAC

- Mechanical effect
  - Dynamic tissue formation
  - Stimulating regenerative cells
- Open wounds 125mmHg
  - 25mmHg (21% granulation tissue)
  - 500mmHg (5.9% granulation tissue)



• McNulty AK et al. Wound Repair Regen 2007  
• Saxena V et al. Plast Reconstr Surg. 2004  
• Morykwas MJ et al. Ann Plast Surg 2001  
• Morykwas MJ, et al. Ann Plast Surg. 1997;38:553-562.

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## What does the VAC do for us?

- Theory 1
  - Tissue strain increases
    - Mitogenesis
- Theory 2
  - Evacuation of excessive interstitial fluid and effect on capillary circulation
  - Decreases local cytokines and inflammatory markers
  - Helps with allowing normal O<sub>2</sub> and CO<sub>2</sub> and nutrient exchange



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## VAC

- Does NOT sterilize the wound
- ? delay time until flap



• Barnaby (2007) Herscovici (2003)

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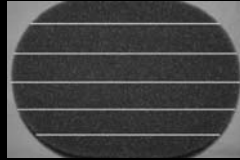
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## VAC and infection

- No consistent decrease in bacterial colonization
  - 6 acute and 19 chronic wounds
- VAC changed q3-5 d



May help with G(-)'s and may not with G(+)'s

• Weed et al. Ann Plast Surg 2004

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## Is the "Expensive Sponge" Necessary?

Ann Plast Surg, 2011 Jun 27.  
A Prospective Randomized Trial Comparing Subatmospheric Wound Therapy With a Sealed Gauze Dressing and the Standard Vacuum-Assisted Closure Device.  
Dorafshar AH, Franczyk M, Gottlieb LI, Wroblewski KE, Lohman RF.

- 87 patients
  - 45 wall suction & gauze dressing
  - 42 Vacuum machine & VAC sponge
- No difference in:
  - Reduction wound Surface Area
  - Reduction wound Volume
- Difference in PRICE:
  - \$4.22 vs \$96.51

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## "Incisional VAC"

- Use intervening non-adhesive dressing
- No direct contact of sponge with skin
- 75mmHg
- 2-4 days



• Webb LX. Use of VAC in managing Orthopaedic wounds - Experience in 191 cases. Presented at the Symposium on Vacuum Assisted Closure and Management of Wounds: June 26, 2000; Hilton Head, SC

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## Incisional VAC Practical

### “Sealed Dressing” benefits

- “Sealed Dressing”
  - ICU patients
  - High risk patients
- Low complications of dressing
  - Peri-incisional blisters
  - Maceration minimally
- Decreased post-op drg
  - VAC vs gauze post-op
  - 1.8 vs 4.8 days



• Stannard J et al. J Trauma 2006

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## Over Skin Graft?

- STSG recipient site
  - Edema control
  - Compression
  - Decreased shear
  - 75mmHg / 3-5 days
  - 97-98% success rate
    - 81% historical controls



• Genecov DF et al. Ann Plast Surg 1998  
• Blackburn JH et al. Ann Plast Surg 1998  
• Simman R et al. Wounds 2004  
• Schneider AM et al. Plast Reconstr Surg 1998

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## VAC

J Orthop Trauma, 2007 Jan;21(1):11-7.

The use of negative-pressure wound therapy (NPWT) in the temporary treatment of soft-tissue injuries associated with high-energy open tibial shaft fractures.; Dedmon BT, Kortesis B, Pungler K, Simpson J, Argenta J, Kulp B, Morykwas M, Webb LX.

- Similar infection rates to historical controls
- Trend to decreased need for flap coverage

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### VAC in combat

- Combat related injuries
  - Exposed tendon (n=16)
  - Exposed bone (n=7)
- VAC + (10 weeks!)
  - Serial I&D (avg 46 days)
  - Dermal substitute (avg 19 more days)
  - STSG (avg 5 more days)
- **NO INFECTIONS !!!**
  - Sealing effect?
  - Prevention of coloniz.?



• Helgeson et al

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### May decrease complexity of coverage

- Decrease the need for complex soft tissue reconstructions
  - 21 pts (6 tibia, 10 F&A, 5 other)
  - 77% at bedside
  - Avg use 19.3 days
  - 57% no further treatment or STSG
  - 43% free tissue transfer



• 5 months s/p Lateral Arm Flap  
• Placed Post-injury Day 22

• Herscovici et al. JOT 2003

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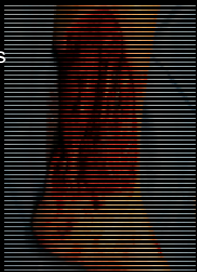
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### Can the VAC allow for delayed flap coverage?

- 111 open tibia fxs w/ free flaps
  - Acute (1-7 days)
  - Subacute (8-42 days)
    - VAC'd
    - Not VAC'd
  - Chronic (>42 days)



• Rinker B et al. Plast Reconstr Surg. 2008  
• Steiert et al. J Plastic, Recon & Aesthetic Surgery 2009

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### Can the VAC allow for delayed flap coverage?

- Subacute (8-42 days)
  - VAC'd vs Not VAC'd
- Looked at:
  - Total Complications 35% vs 53%
  - Infection Rate 6% vs 18%
  - Flap Complications 12% vs 21%



Rinker B et al. Plast Reconstr Surg. 2008

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### Can the VAC allow for delayed flap coverage?

- Subacute (8-42 days)
  - VAC'd vs Not VAC'd
- Looked at:
  - Osseous Union (months) 4.9 vs 7.2
  - \*Same as Acute Coverage group\*



Rinker B et al. Plast Reconstr Surg. 2008

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### Take Home Points

- 1) Need Bony stability to help soft tissue
- 2) Immediate Appropriate Antibiotics → Treatment
- 3) Urgent ??? (certainly NOT emergent) thorough I&D
- 4) Early Closure if possible over drain (Grade 1-3a)
  - Consider Incisional VAC
- 5) If staging open wound for delayed closure / flap:
  - Antibiotic Beads
  - VAC if soft tissue over bone
- 6) Flap within 10 days if possible?
  - VAC may decrease need for flap
  - VAC may decrease complexity of flap needed
  - VAC may buy more time until flap

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